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ON AN EARLY TERTIARY LAND-CONNECTION BETWEEN NORTH AND SOUTH AMERICA

R. F. SCHARFF, PH.D., B.SC.
NATIONAL MUSEUM OF IRELAND, DUBLIN

THAT the two great continents—North and South America—have only become joined to one another by land in later Tertiary times, is a widely accepted assumption. Yet the various authorities who have made this problem a subject of special investigation have not all come to precisely the same conclusions as to the geological age during which this union of the two continents was brought about.

A study of the marine fishes on both sides of the isthmus of Central America, for example, convinced Dr. Günther[1] that up to a recent geological period the latter was only represented by a chain of islands similar to that of the Antilles. But the number of species of fishes on the Atlantic and Pacific coasts of Central America that were supposed to be identical has been considerably reduced during more recent surveys. They no longer amount to more than 4.3 per cent. of the total number of fishes known to occur in both areas. Professor Jordan[2] on that account maintains that the isthmus has not been depressed during the lifetime of most of the existing species. The submergence, he argues, must have supervened at a more remote time. In the belief that the

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[1] Günther, A. C. L. G., "Study of Fishes," p. 280.

[2] Jordan, D. S., "Study of Fishes," Vol. I, pp. 274–280.

Miocene may be taken as the date of origin of the modern genera of marine fishes, he contends that an open communication between the two oceans may have existed during that geological period. It is important to note that the sea currents seem at that time to have set westward, thus favoring the transfer of Atlantic rather than Pacific types across the isthmian area.

Mr. Regan[3] is inclined to put the date still a little further back in urging that the marine connection between the two oceans ceased to exist at the beginning of the Miocene.

An investigation of the Crustacea and their distribution led Dr. Ortmann[4] to the conclusion that at the dawn of the Tertiary era an oceanic connection was in actual existence between the Atlantic and the Pacific in the isthmian region. This communication, he thinks, persisted until the Miocene. In the commencement of that period the isthmus was elevated, thus joining North and South America.

The Mexican amphibians and reptiles have been utilized by Dr. Gadow[5] in the solution of the same interesting problem with the result that he assumes the establishment of land-continuity between North and South America in either late Oligocene or early Miocene times.

The whole character of neotropical zoology, remarks Dr. Wallace,[6] whether as regards its deficiencies or its specialties, points to a long continuance of isolation of South America from the rest of the world, with a very few distant periods of union with the northern continent.

Geologists have discussed this subject mostly from paleontological evidence. Professor Gregory[7] clearly demonstrated that the idea of an interoceanic connection as late as the Pleistocene period, as suggested by Dr. Spencer,[7a] could no longer be entertained. In arriving

[3] Regan, C. T., ''Fishes of Central America,'' p. xxx.

[4] Ortmann, A. E., ''Geographical Distribution of Decapods,'' p. 359.

[5] Gadow, H., ''Mexican Amphibians and Reptiles,'' p. 236.

[6] Wallace, A. R., ''Distribution of Animals,'' Vol. II, p. 80.

[7] Gregory, J. W., ''Palæontology of the West Indies,'' p. 305.

[7a] Spencer, J. W., ''Reconstruction of an Antillean Continent,'' p. 134.

at a final decision as to the approximate date of orgin of the Central American land bridge, he was mainly influenced by Professor Scott's reference to the occurrence of Caryoderma a supposed glyptodont edentate in the Miocene Loup-Fork deposits. He urged, therefore, that the waterway across Central America was in all likelihood finally closed in the lower Miocene or possibly even in the upper Oligocene. As Caryoderma, however, is now believed to be a reptile and not an edentate, this argument no longer holds good.

Less definite are the results obtained by Dr. Hill[8] after a careful study of the rocks near the Isthmus of Panama. The only geological periods, he thinks, since the Mesozoic era, during which the Pacific and Atlantic Oceans could have been in communication with one another, would be the Eocene or Oligocene. It is important to note that Dr. Hill's conclusions were based entirely on his observations at the Isthmus of Panama. The geology of the remainder of Central America is as yet too imperfectly known to form the basis for similar speculations.

The most important pronouncement perhaps which has yet been made on the subject under discussion is that by Professor Osborn.[9] His intimate knowledge of the fossil terrestrial mammals of North America enabled him to affirm that North and South America were joined to one another more than once, as Wallace had suggested. The first union occurred in Mid-Cretaceous and perhaps early Tertiary times. Hereafter the continents separated once more until the Pliocene period.

Dr. Smith Woodward,[10] Mr. Lydekker and also Professor Depéret[11] hold similar views with regard to the more recent junction of the two continents.

The evidence on which Professor Osborn based his belief in the first and much earlier land connection between North and South America was unknown when Mr. Lydekker[12] wrote his work on the Geographical History of Mammals. He was under the impression, therefore, that the mammalian fauna of the South American region had been totally isolated from that of North America up to about the end of the Miocene. I shall shortly return to Professor Osborn's views as soon as I have completed my brief historical review of the first problem.

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[8] Hill, R. T., "Geological History of the Isthmus of Panama," p. 269.

[9] Osborn, H. F., "Mammalian Palæontology," p. 99.

[10] Woodward, A. S., "Palæontology," p. 429.

[11] Depéret, C., "Transformations of the Animal World," p. 282.

Professor Lapparent[13] concurs with Mr. Lydekker's opinion that the interchange of waters between the Atlantic and Pacific oceans across Central America could only have ceased to exist at quite the end of the Miocene period.

Finally, in his treatise on the development of continents, Dr. Arldt[14] maintains that the Central American land bridge must have originated at the commencement of the Pliocene period, and with this view I fully agree. Part of Central America no doubt had already risen above the ocean at a much earlier period, but in its present outlines and extent it must be regarded as a geologically recent development.

All those in fact who have seriously considered the problem, either from the standpoint of a marine or a terrestrial zoologist or from that of a paleontologist concur in the opinion that North and South America were separated from one another by a marine channel or by wide seas during part of the Teritary era. This, however, is the only point in which there is a general agreement. While some contend that the junction between the two continents had only been effected in comparatively recent geological times, others hold that within the life history of the great class of mammals, either in the early Tertiary or late in the Secondary era, a land bridge between North and South America had once before existed, by means of which an interchange of the faunas could have been brought about. It is this supposed earlier land connection and its probable nature and extent that I wish to discuss.

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[12] Lydekker, R., "Geographical History of Mammals," p. 119.

[13] Lapparent, A. de, "Traité de Géologie," p. 1318.

[14] Arldt, Th., "Entwicklung der Kontinente," p. 597.

Dr. Wallace already vaguely indicated that there may have been several very distant periods of union in the past of the Southern with the Northern continent. This supposition received a startling confirmation by the discovery first by Dr. Wortmann and then by Professor Osborn[15] of true armadillo remains in the middle Eocene beds of Wyoming. If he does not actually speak of a direct land connection between the two continents in early Tertiary times, Professor Osborn[16] suggests as much in his remark that this discovery "adds another fact to the growing evidence that North and South America were related in the Mid-Cretaceous and perhaps early Tertiary and then separated again until the Pliocene." He does not specify in any way in what manner this relationship had been brought about. His views would be of particular interest, considering that Dr. von Ihering's extensive zoological and botanical researches have led him to believe that the South American continent itself must be of comparatively recent geological origin.

The latter declares that South America had arisen as a continent only since the Oligocene period. It then consisted of two parts united by a narrow strip of land in the west, which later on developed into the great mountain chain of the Andes. These two parts, which he calls "Archiplata" and "Archiguiana," were previously separated from one another. The first embraced Chile, Argentina, Uruguay and southern Brazil, the other the highland of Venezuela and Guiana. Each of these possessed, according to Dr. von Ihering,[17] its own characteristic fauna and flora and these were totally distinct from one another.

A somewhat similar theory as to the origin of South America, largely based on the geographical distribution of fresh-water decapods, has been advanced by Dr. Ortmann.[18] In place of the present Southern continent he thinks that toward the end of Mesozoic times, there existed the old Brazilian land (Archiplata), an Antillean continent (including the West Indies and Venezuela) and also the Chilean coast range. These three land masses were separated from one another by wide oceans. Just before the close of the Secondary era the Antillean continent, and with it Venezuela and even the Galapagos Islands, became united with western North America, the latter being then still detached from eastern North America. When Venezuela in early Tertiary times at last became fused with the other larger South American land masses, the interoceanic connection across Central America had severed it from North America.

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[15] Osborn, H. F., "An Armadillo from the Middle Eocene," pp. 163-165.

[16] Osborn, H. F., "Mammalian Palæontology," p. 99.

[17] Ihering, H. von, "Archhelenis and Archinotis," p. 79.

Under such geographical conditions the Wyoming edentates alluded to by Professor Osborn could only have been derived from Venezuela, it being the sole portion of the present Southern continent that had any relationship with North America in those remote times. No fact, however, has been brought to light, either in the recent or fossil history of the edentates to lead us to imagine that they had originated in the northern part of South America.

That South America owes its origin to the union of several independent land masses is so clearly indicated by the existing fauna of the continent, that a similar evidence should also be revealed by a study of its rocks and fossils.

The geology of South America is unfortunately as yet little known. Yet even such a cautious observer as Professor Suess[19] ventured to suggest, on stratigraphical grounds, that an arm of the sea may have penetrated right across the continent in Cretaceous times. The archaic rocks of eastern Brazil and Guiana certainly were then raised above the sea, since the younger formations appear to be superimposed with great regularity further and further to the west of this ancient formation. Dr.

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[18] Ortmann, A. E., ''Geographical Distribution of Decapods,'' pp. 365–366.

[19] Suess, E., ''Antlitz der Erde,'' Vol. II, p. 683.

Katzer[20] contends that during part of the Mesozoic era the Pacific ocean extended eastward to the shores of this land, whose rivers then drained westward into the ocean, as they even continued to do until Miocene times.

While it is therefore by no means evident from the geologist's point of view how and when the various land masses became joined to form the present South America, the geographical distribution of the living fauna, together with a study of the paleontology, has furnished most valuable hints as to the probable geological history of the continent.

Dr. Gill claims that the fishes are among the best indicators of former geographical conditions. Turning to the most recent studies on the South American fish fauna, those of Professor Eigenmann,[21] we find that he also is impressed by the dissimilar elements of which it is composed. He explains this varied character of the fauna by the supposition that two independent land masses, originally separated in the region of the Amazon valley, became welded together in early Tertiary times.

In his attempted restoration of the geographical conditions of South America during the Eocene period, Professor de Lapparent[22] depicts an aspect contrasting with that of other observers, and yet he recognizes a division of South America into two parts, for he represents the continent as being dissevered by a marine channel between the Rio Negro in Argentina and Southern Peru.

Of all the maps illustrating ancient distribution of land and water, that of Dr. Arldt[23] is the most striking in originality. He connects northern South America in late Cretaceous times by land with western Mexico, but not by way of Central America. He assumes that the latter was submerged at that time and that an independent land bridge extended from southwestern North America through the Galapagos Islands to Colombia. This northern complex of land was isolated from the southern part of South America by a wide sea channel stretching right across the continent.

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[20] Katzer, F., ''Geologie des Amazonengebietes,'' p. 254.

[21] Eigenmann, C. H., ''Fishes of South and Middle America,'' p. 528.

[22] Lapparent, A. de, ''Traité de Géologie,'' p. 1455.

[23] Arldt, Th., ''Entwicklung der Kontinente'' (map 19).

His conception of an extensive land having once flourished to the west of Central America, while the latter was largely submerged, is not altogether new. In alluding to the east-westward trend of the Antillean Cordillera and its abrupt termination on the Pacific coast of Guatemala, Professor Suess[24] makes a suggestion as to its former westward prolongation. Precisely at the point, he says, where the arcuate continuation of this chain might be expected to meet the principal chains of South America, lie the volcanic Galapagos Islands.

Various indications in the structure of the Isthmus of Panama moreover left the impression on Dr. Hill's[25] mind that large areas now covered by the Pacific, to the west of the isthmus, were once replaced by an extensive land surface.

Nothing more, however, can be deduced from geological testimony as to the presence of any land connecting North and South America at a time when Central America may have been still wholly or partially submerged. Nor can we even surmise from these suggestions at what geological period such hypothetical land may have existed. Other methods will have to be employed in order to discover the manner by which the Eocene armadillos reached North America.

If we examine the whole eastern Pacific coast line from Alaska to Cape Horn, we notice that there are two areas that have apparently remained entirely unsubmerged since Jurassic times to the present day. One of these occupies part of western Mexico and Lower California, the other a strip of the southern coast line of Chile. It is the latter coast cordillera which Dr. Burckhardt[26] believed to be the remaining remnant of a mighty Pacific continent, because porphyritic conglomerates of Cretaceous age are heaped against its eastern flank, whereas still further east the latter grade into fine-grained rocks, thus indicating that the land from which they were derived lay westward, out in the ocean.

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[24] Suess, E., ''Antlitz der Erde,'' Vol. II, p. 263.

[25] Hill, R. T., ''Geology of the Isthmus of Panama,'' p. 217.

[26] Burckhardt, C., ''Traces géologiques d'un continent,'' pp. 12–14.

While we need not here dwell upon the theory of a former Pacific continent[27] so ably supported by Professor Haug on purely geological grounds and by Professor Hutton on zoogeographical data, I should like to draw attention to some features in the geographical distribution of animals and plants which prove that southwestern North America and southwestern South America are intimately related to one another in their fauna and flora. This relationship can not be explained as the product of a similarity in soil and climatic conditions. It is not a case of mere convergence. It can be shown that it already existed in the distant past, and I venture to think that this relationship implies the presence of a former direct land connection between these two ancient areas, when the continent of South America was still in the making.

It was Dr. Wallace[28] who first directed attention to the remarkable fact that many genera of insects from the north temperate regions reappeared in temperate South America, being generally absent in the intermediate stations. He explained this phenomenon by the supposition that the northern forms had traveled southward during successive glacial epochs when the mountain range of the Isthmus of Panama might have become adapted for their advance in that direction. Their southward passage was believed to have been facilitated by storms and hurricanes which carried the insects across unsuitable territories.

This interpretation of a striking feature of geographical distribution seems to have been considered satisfactory at the time. At any rate no one has raised any protest so far as I am aware. Yet I am not at all disposed to admit its correctness.

[27] More detailed information on the theories relating to an ancient Pacific continent will be published in my work on the geological history of the American fauna.

[28] Wallace, A. R., ''Distribution of Animals,'' Vol. II, pp. 45–47.

Let us take, for example, the case of Carabus, a genus of running beetles so familiar to North American entomologists. They are by no means easily transported to great distances by gales and hurricanes as Dr. Wallace avers, for the simple reason that these beetles can not fly. Their wing cases are permanently soldered together, and being generally found under clods of earth or beneath stones, the action of winds can have no appreciable influence on their dispersion. They are typical inhabitants of the northern hemisphere, being abundant in Europe, northern Asia and North America. A single species occurs in western Mexico. No Carabus has ever been taken in Central America or in the northern or middle states of South America. Yet in Chile and spreading into Argentina, no less than eleven species have been observed. For a distance of about fifty degrees of latitude the running beetles of the genus Carabus are quite absent and then reappear further south in numbers. Those entomologists, like Mr. Born,[29] who have made a special study of the Carabidæ, consider them eminently fitted for the purpose of demonstrating former changes of land and water.

Of the northern genera of butterflies Colias, Lycæna and Argynnis, which occur in Chile, the presumption, at any rate is admissible that they might have been transported to these far distant southern latitudes by accidental or occasional means of dispersal, such as those suggested by Dr. Wallace. Yet the case of the ant Lasius, a northern genus, which reappears in Chile, is more difficult of explanation on such an hypothesis.

We can not say of any of these invertebrates that they are confined to western Mexico in North America, though this appears to be the most southerly point on the northern continent where they occur. On the other hand the primitive earthworm Kerria is only known from Lower California and from the southern part of South America in Chile and Argentina. From the latter country it seems to have spread into Paraguay and southern Brazil.

[29] Born, Paul, "Zoogeographisch-Carabologische Studien."

Of particular importance is the ancient genus of land molluscs Bulimulus. It is quite peculiar to America. Its nearest relation appears to be the Melanesian Placostylus. Bulimulus, which is almost characteristic of the west coast of America, is now divided into three great groups, one of which has its headquarters in Chile and Peru, the second is met with on the Galapagos Islands, Central America and the West Indies, the third is confined to Lower California and Mexico. These three groups are very similar in appearance, but Dr. Pilsbry[30] maintains that this resemblance, which is particularly noticeable between the Mexican and Chilean forms, is not so much a proof of close relationship as the result of similar environment. At any rate we notice here three distinct and discontinuous centers of radiation, two of which are situated on very ancient land surfaces, while the third mostly occupies islands whose origin certainly dates back to early Tertiary times.

Probably a still more ancient invertebrate is the curious Peripatus, an archaic arthropod with an extremely discontinuous distribution. Three distinct groups inhabit America. One of these is confined to southern Chile, another seems to have spread northward along the Andes from a Chilean center as far as Ecuador. At a distance of twenty degrees of latitude north of this northern outpost it reappears in western Mexico, while in Central America lives a third and perfectly distinct group which has spread thence to the West Indies and eastern South America.

In its three distinct centers of distribution all along the west coast of America it bears a certain resemblance to the range of Bulimulus just alluded to. The range is certainly suggestive of a very ancient and more direct communication than obtains at present between western Mexico and Chile.

The flora of the new world retains far more pronounced traces of that curious relationship between the southwestern areas of its two continents. The plants of both Chile and southwestern North America, moreover, are better known than are the animals. Whatever may be the cause, not only is there a resemblance between families and genera in the two areas; the general similarity of the landscape and especially the occurrence in both of a profusion of cactuses strikes the casual observer at once. Many specimens of northern plants recur in identical forms in those distant regions of South America.

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[30] Pilsbry, H. A., "Manual of Conchology," Vol. X, p. 127.

Professor Asa Gray[31] and Sir Joseph Hooker long ago directed attention to this very remarkable phenomenon.

More recently, Professor Engler[32] and Professor Bray have emphasized this affinity and speculated on the problems connected with it. The flora of the Rocky Mountains including the Sierra Nevada Mountains above the transition zone, and the mountains far to the south of them, though separated from one another by a stretch of some ten degrees of latitude of moist tropical country, abound in northern genera of plants such as Ranunculus, Anemone, Geranium, Spiræa, Geum, Rubus, Saxifraga, Vaccinium, Gentiana, Hieracium and others. The greater number of forms occurring in the southern continent are endemic, pointing to long-continued isolation. Yet certain species, even of the Rocky Mountain Arctic alpine region, reappear in the extra-tropical Andes towards the southern extremity of South America, being, so far as is known, wholly absent from the Mexican mountains as well as the tropical Andes. Among these Professor Bray mentions particularly *Gentiana prostrata, Trisetum subspicatum, Primula farinosa* and its variety *magellanica, Draba incana, Alopecurus alpinus, Saxifraga cespitosa, Polemonium microcanthum* and *Collomia gracilis.*

The lower Sonoran elements of plant life are likewise represented in the extreme south. *Oxytheca dendroidea, Chorizanthe commissuralis* and *Lastarriœa chilensis,* for example, do not occur in the vast regions that separate the two areas. A few of these plants may possibly have been casually introduced from the one to the other. But Professor Bray[33] expresses the opinion that in most cases we have to deal with forms which were connected by a remote ancestry, and which flourished at a time and under conditions which permitted a more general distribution.

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[31] Gray, A., and J. Hooker, "Vegetation d. Rocky Mountain Gebietes," p. 292.

[32] Engler, A., "Entwicklungsgeschichte d. Florengebietes," Vol. II, p. 256.

What these conditions were like he does not venture to inform us, but it must be evident that this flora is much older than the Pleistocene, during which time it has been supposed that the climatic conditions may have favored a southerly advance of northern forms. Specific changes, among certain plants as well as among some animals, seem to proceed with extreme slowness. We have the example of the still living redwood tree (*Sequoia sempervirens*) which has persisted unchanged since Mesozoic times, for the fossil *Sequoia Langsdorfi* is now considered identical with the modern form.

It appears to me possible, therefore, that the well-known and extremely discontinuous range of some of the alpine plants may be interpreted by the assumption that, like Sequoia, they are of vast antiquity and that they have spread along a continuous mountain chain which once extended in a direct line from southwestern North America to western Chile, before the Andes had risen from the floor of the ocean.

We know that a similar relationship between North America and southern South America prevailed already in Mid-Cretaceous times. No less than seventy-five per cent. of the plant remains recently discovered in a Mid-Cretaceous plant-bearing layer in Argentina are characteristic types of the Dakota-group flora.

Commenting on this discovery, Mr. Berry[34] dwells on the remarkable agreement of this southern flora with that developed in Mid-Cretaceous times in western North America. He urges that it certainly points to a community of origin. In these ancient South American deposits all the familiar northern genera Liriodendron,

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[33] Bray, W. L., "Relations of the North American Flora," pp. 709–716.

[34] Berry, E. W., "Mid-Cretaceous Geography," p. 510.

Liquidambar, Cinnamomum and Sassafras are met with. Even Platanus, Populus, Quercus and others are represented. No wonder that Mr. Berry[34] came to the conclusion that a geographical connection must have existed between North and South America during Mid-Cretaceous times. He thought that the plants referred to had spread southward from the north, while Professor Osborn favors the view that his Eocene Armadillo had advanced from the south.

Before concluding this short review on the evidences pointing to an early Tertiary direct land bridge between the southwestern portions of North and South America, a few observations on the paleontology of Patagonia and Chile may somewhat elucidate this interesting problem.

Edentates occur in the oldest Tertiary deposits of Patagonia or even pre-Tertiary, if Dr. Florentino Ameghino[35] is correct in assigning a Mesozoic age to the latter. The position which this savant has taken up and so courageously defended has been almost universally assailed. Professor Ameghino still holds that the now famous fossiliferous strata of Santa Cruz, which have yielded such a surprisingly rich harvest of mammalian remains are of Eocene age, while the likewise terrestrial Notostylops beds belong to the Cretaceous series.

The great majority of geologists, on the other hand, are of opinion that the Santa Cruzian deposits belong to the Miocene and the Notostylops beds to the Eocene period.

These beds are separated by marine strata which have been carefully investigated by the members of the Princeton Expedition to Patagonia. The invertebrates collected were described by Dr. Ortmann,[36] who considered them as certainly of Miocene age. He thus concurs in the opinion arrived at independently by the many eminent paleontologists, that both the terrestrial deposits above alluded to, the Notostylops and Santa Cruzian beds, are of Tertiary age.

[35] Ameghino, Flo., ''Formations sédimentaires de Patagonie.''

[36] Ortmann, A. E., ''Princeton Expedition,'' p. 288.

To all appearances the question was finally settled when Dr. von Ihering[37] again challenged the results obtained by Dr. Ortmann, pointing out certain discrepancies in his determinations. Dr. von Ihering now maintains that only 4.9 per cent. of the species from the Santa Cruz marine beds are still living and, as the formation moreover corresponds to those of Oamaru in New Zealand and of eastern Australia, now generally included in the Eocene, he feels no hesitation in placing the Patagonian marine beds in the latter series. He, therefore, entirely supports Dr. Fl. Ameghino's latest views as to the Eocene age of these strata.

If Dr. von Ihering's conclusions are substantiated, and his arguments appear to me convincing, the more recent terrestrial Santa Cruzian deposit must be either of Oligocene, or as Dr. Ameghino believes, of Upper Eocene age.

Let us for a moment consider the geographical conditions in early Tertiary times of that region of South America in which these beds are found. The similarity in character of the Patagonian marine fauna on the east coast with the Tertiary of northern Chile on the west coast of the continent implies the existence of a connection between the two oceans. This supposition is further strengthened by the fact that eight per cent. of the eastern or Patagonian species of marine mollusca are found in the western Tertiary beds of Navidad in Chile.

Since a number of northern types of molluscs make their appearance in the upper divisions of the Patagonian beds, Dr. von Ihering suggests that the supposed old land connection between Brazil and Africa had at that time been ruptured, thus opening a way for an invasion of the northern fauna. I have not previously alluded to this land bridge, Ihering's southern Atlantis or Archhelenis, because I am not dealing with this problem at present. It is not necessary, however, to conclude from the presence of northern molluscs in the upper Patagonian marine beds that this supposed land bridge had broken down completely in upper Eocene times. They could just as well have come from the Pacific, which seems to have freely communicated with the Atlantic across Patagonia. Not only are these northern invaders present in the Chilean deposits on the Pacific coast, there are many genera in the latter according to Dr. von Ihering,[38] such as Conus, Purpura, Oliva, Cassis, Cypræa and Littorina which never penetrated as far east as Patagonia at all. They thus denote the manner of dispersal of all the northern forms from north to south, and it appears as if they had gradually crept southward along some ancient coast line. But since there is no reason to suppose that the present Pacific coast of South America had come into existence already in early Tertiary times, we may assume that the ancient coast line lay farther west.

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[37] Ihering, H. von, "Mollusques fossiles de l'Argentine," p. 95.

Down to Miocene times the influence of the Caribbean and even the European marine fauna continued to be felt on the Pacific side of South America. Dr. Ortmann[39] tells us that the north Peruvian Miocene fauna shows close affinities with the faunas alluded to. Several observers remarked on the circumstance that when Central America was submerged in early Tertiary times, the Caribbean and Atlantic species generally seemed to be drawn towards the Pacific by a strong current. We have noticed that the effects of this current in carrying northern Atlantic forms are traceable in the Tertiary deposits all along the Pacific coast of South America as far south as northern Chile and even on the Atlantic side of the continent in Patagonia, which then freely communicated by a marine channel with the Pacific.

On the other hand, the Tertiary molluscs of Chile and California are very distinct from one another. This apparently implies that a barrier was interposed between the northern coasts of California or rather between the main portion of the Pacific coast line of North America and that of South America. Hence it tends to support my argument, that western Mexico and part of lower

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[38] Ihering, H. von, "Mollusques fossiles de l'Argentine," p. 514.

[39] Ortmann, A. E., "Tertiary Invertebrates of Santa Cruz," p. 320.

California had a direct land connection with Chile. Dr. von Ihering[40] suggests that the Antillean arc which is continued to Guatemala and there abruptly terminates on the Pacific coast may have been continued westward in early Tertiary times in a great peninsula comprising the Galapagos and Sandwich Islands. He applied the term "Pacila" to it.

My reason for preferring to connect western Mexico and Chile in the manner I conceived, rather than adopt Dr. von Ihering's proposal, is that the spreading of Caribbean and Atlantic shallow water forms of molluscs indicates a continuous shore line running north and south.

The Pacific coast of South America as it appears today had not yet emerged in early Tertiary times. The Andes were only just beginning to make their appearance. They must have risen as a series of islands parallel to the ancient coast that lay out in the west.

I picture to myself southern Chile as forming the extreme apex of a long penisula extending southward from western Mexico. Sometime during the Eocene period it became disconnected from Patagonia. The long peninsula was subsequently more and more reduced in size until only high mountains, such as the volcanic cones of the Galapagos Islands, remained above water. The peculiar lizards belonging to the genera Amblyrhynchus and Conolophus inhabiting these islands have their nearest relation in Phymaturus, which is confined to Chile, and not as we might expect to the much less distant Peru, Ecuador or Colombia. As long as any parts of the peninsula remained above water and attached to Mexico, it may have added its mammalian fauna to that of North America.

In such a manner it may possibly have come to pass that the northern genus of porcupine Erethizon is, according to Professor Scott, more like the fossil Steiromys from the Santa Cruz beds than the latter is to any of the South American porcupines. Steiromys, as Professor

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[40] Ihering, H. von, "Archhelenis und Archinotis," p. 318.

Scott[41] informs us, is only a little more primitive than Erethizon, the change from the one to the other involving but a slight modification.

Erethizon is unknown in North America from pre-Pleistocene deposits, but there is no reason to assume that it had not originated long before the Pleistocene period. South American types of mammals may have existed in western North America from early Tertiary times onward without having left their remains in the more ancient deposits.

The theory of the former existence of a great lobe of land connecting western North America with southern South America during the beginning of the Tertiary era, while Central America and northern South America were still largely submerged is sustained by many facts in the geographical distribution of plants and animals. It seems to me to explain the undoubted affinities prevailing in the two areas in a better manner than by any other hypothesis. Against it may be urged that it is an unwarranted supposition to assume that existing species of plants can have preserved their specific characters since the Eocene period. Still we must not forget that one plant at least, *Sequoia sempervirens,* has lived without any appreciable change down to the present time from those remote ages. And even if we altogether eliminate the testimony elicited from a botanical source, there still remain zoological factors of importance as buttresses of the hypothetical bridge I have constructed.

May, 1909.

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[41] Scott, W. H., "Mammalia of Santa Cruz," p. 417.

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